



GEO-CAPE – Implementation Concepts: Dedicated Satellite; GOES-R Series; & Geo Quick Ride/Hosted Payloads

**GEO-CAPE Science Working Group Meeting
Sheraton Columbia, Columbia, MD
22-24 September 2009**

Bob Caffrey / NASA



Mission Requirements for Pre-Phase A



Scope of Major Pre-Phase A Activities:

Headquarters

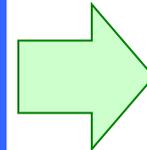
- Approve a Formulation Authorization Document
- Develop DRAFT Level 1 Requirements
- Conduct Acquisition Strategy Planning Meeting

Technical Activities:

- Develop and document preliminary mission concepts
- Conduct internal Reviews
- Conduct Mission Concept Review Project Planning, Costing and Scheduling
- Develop and document a DRAFT Integrated Baseline, including:
 - High level WBS
 - Assessment of Technology Readiness Levels
 - Assessment of Infrastructure and Workforce needs
 - Identification of potential partnerships
 - Identification of conceptual acquisition strategies for proposed major procurements

KDP Readiness

- Obtain KDP A Readiness products
- Approval through the governing PMC



Areas the Science Community must work:

1. Develop DRAFT Level 1 Science Requirements
2. Support development of preliminary mission concepts
3. Support the assessment of Technical Readiness Levels
4. Identify potential partnerships

1. Develop DRAFT Level 1 Science Requirements (Level 1 Requirements Outline, subset)



- 1.0 Scope
- 2.0 Science Definition
 - 2.1 Science Goals
 - 2.2 Science Objectives
 - 2.3 Mission Investigations
 - 2.4 Payloads
- 3.0 Project Definition
 - 3.1 Project Organization and Management
 - 3.2 Science Team Organization
 - 3.3 Acquisition Strategy
- 4.0 Programmatic Requirements
 - 4.1 Mission Success Criteria
 - 4.2 Science Requirements
 - 4.2.1 Baseline Science Requirements
 - 4.2.2 Threshold Science Requirements
 - 4.3 Science Instrument Requirements
 - 4.4 Mission Performance
 - 4.5 Spacecraft Performance
 - 4.6 Launch Requirements
 - 4.7 Mission Data
 - 4.7.1 Science Data Management
 - 4.7.2 Data Management Plan
- 5.0 NASA Mission Cost Requirements
 - 5.1 Mission Cost and Schedule
 - 5.2 Cost Management and Scope Reduction





Level-1 Science Requirements



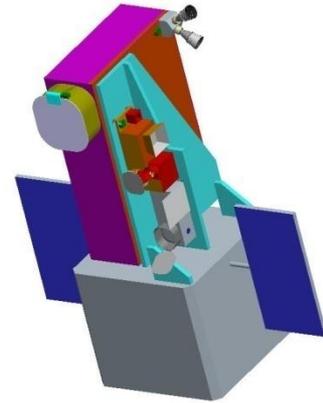
Threshold Science Requirements. The mission performance requirements necessary to achieve the minimum science acceptable for the investment. In some AOs used for competed missions, threshold science requirements may be called the “science floor” for the mission.

Baseline Science Requirements. The mission performance requirements necessary to achieve the full science objectives of the mission.

2. Support development of preliminary mission concepts



- Mission Concept #1 – Dedicated Mission:
 - Orbit: Geostationary, 100°W Longitude
 - Lifetime: 2 year lifetime, 5 year goal
 - Need to request: Orbit slot & Spectrum Allocation
- Mission Concept #2 – GOES Piggyback:
 - Each s/c designed to carry "instruments of opportunity" (IOOs) that use s/c power, communication, & command/control
 - Spacecraft not changed after HES removed (mass/volume avail.)
- Mission Concept #3 – GQR Distributed Mission:
 - 1998/99 GQR Studies on Commercial Spacecraft Opportunities:
 - Average excess capacity: mass: 89kg, power: 460W & volume
 - Vendors: 4 US manufactures & 4 owner/operators



Multiple options to accommodate a payload on a host S/C - each has its benefits and constraints



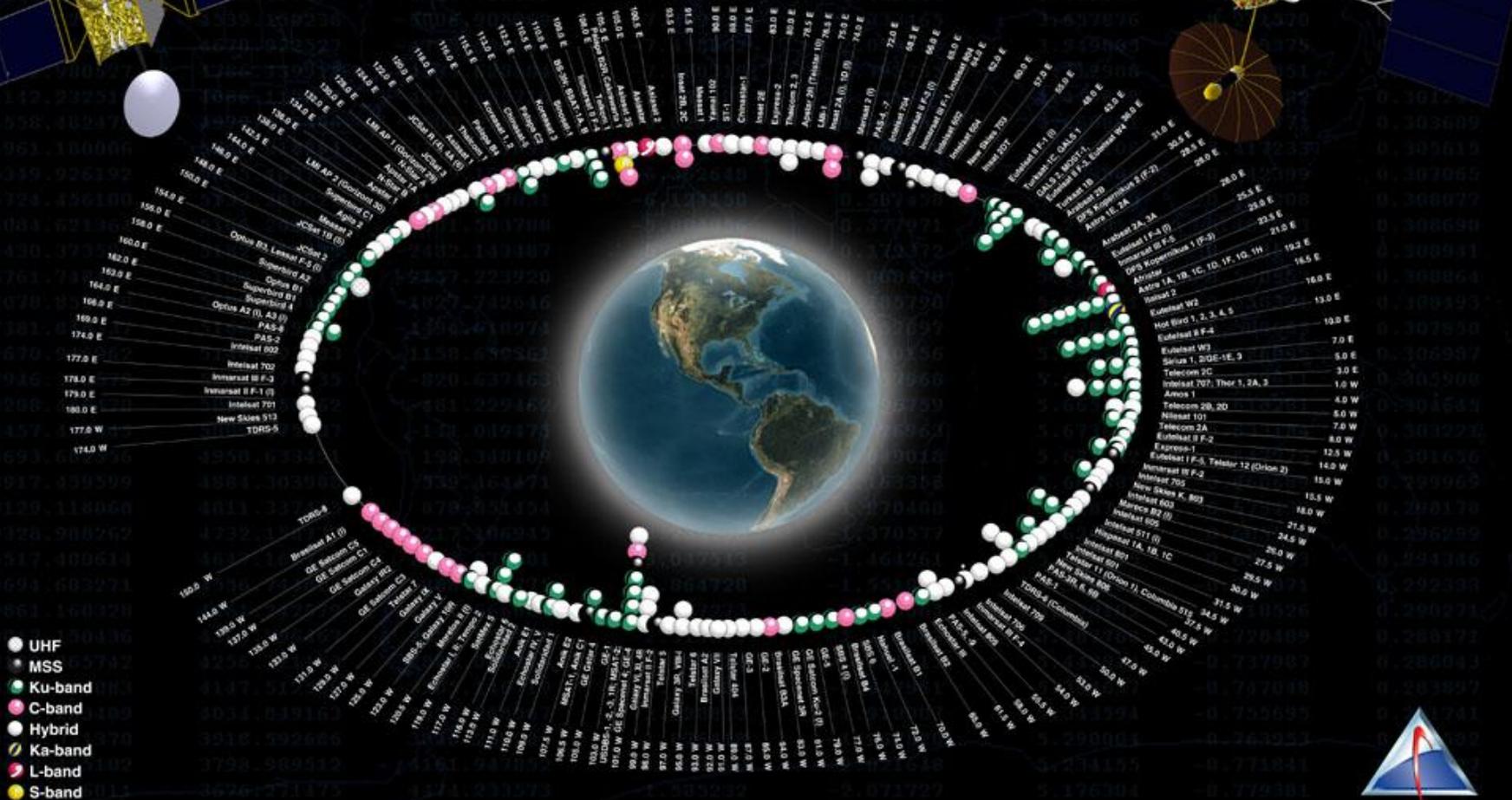
GQR Distributed Mission Options:

- Option 1 – US owner/operator communication satellite
 - Intelsat, SES Americom, EchoStar (WAAS-1, IRIS, CHIRP, GOLD)
- Option 2 – Non-U.S. owner/operator com. satellite
 - Telesat Canada (WAAS-2)
- Option 3 – U.S. s/c for a non-U.S. communication satellite
 - Boeing, Lockheed, Loral, and Orbital
- Option 4 – U.S. s/c for a non-U.S. Space Agency satellite
 - Australia, Brazil, Korea, and more (GIFTS)
- Option 5 – NASA or other U.S. government satellite
 - GOES-R and TDRS (VOLCAM/SEI, GeoTRACE-2)

Communication satellites in the geostationary belt enable a distributed mission

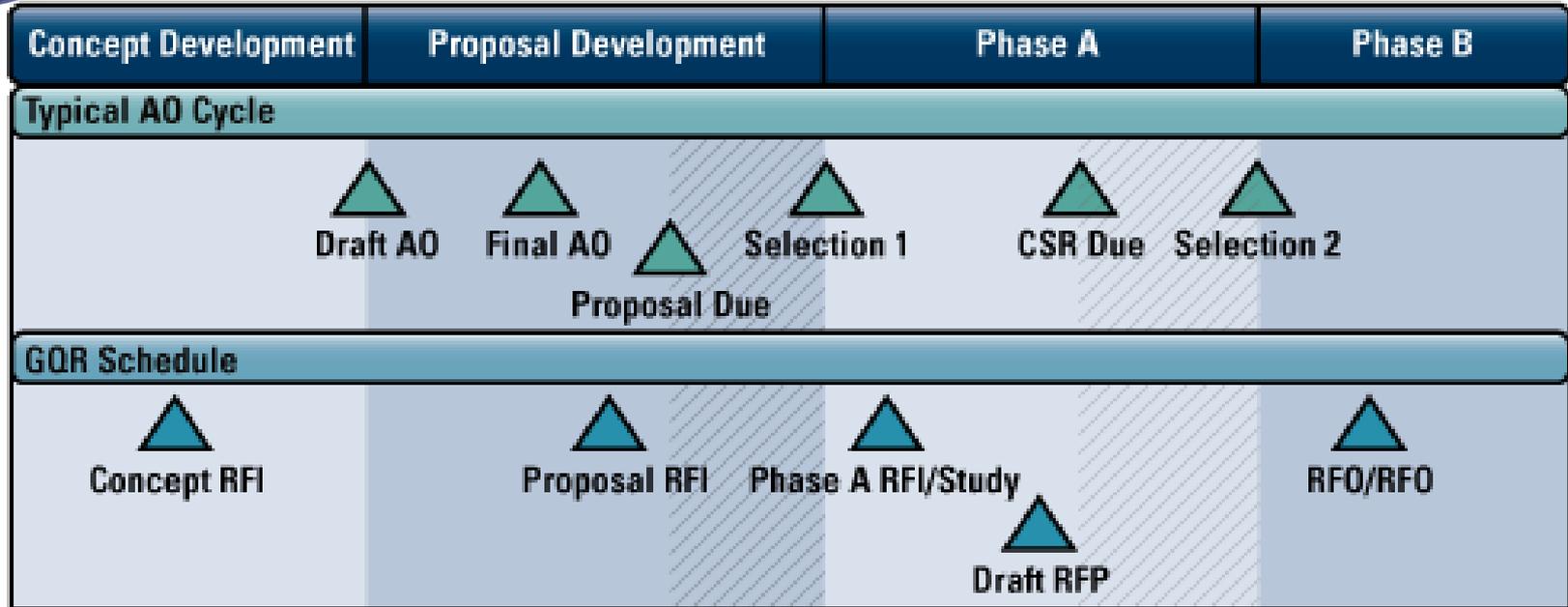


The GEO Belt





GQR Concept/Mission Schedule



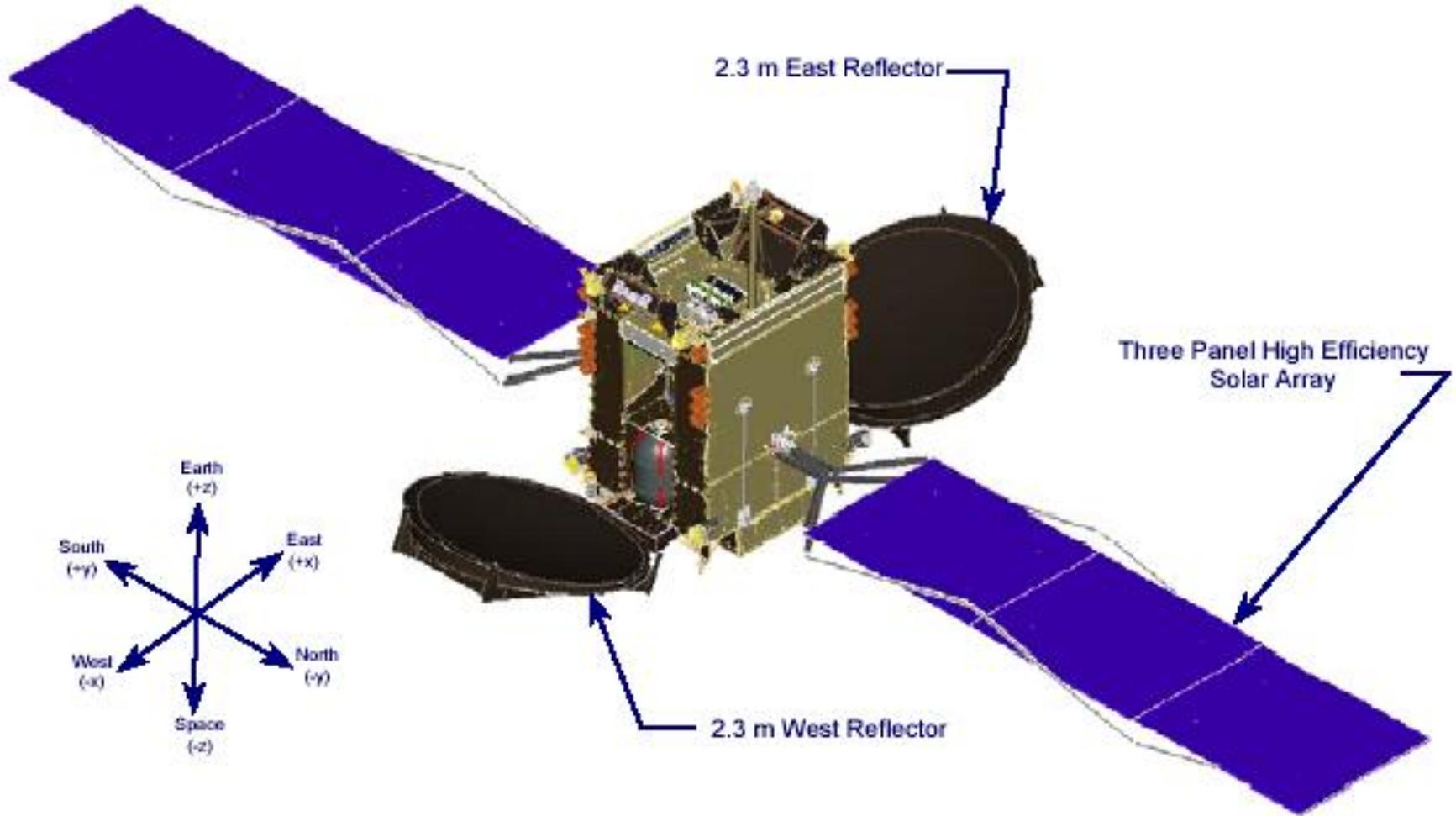
//// = unfunded phase

Unsuccessful GQR Payloads : 1) GeoTROPESAT (1996); 2) GeoExpress (1998); 3) VOLCAM (1998); 4) SEI-1 (1999), 5) GeoTRACE-1 (1999); 6) ESEI (2001); 7) LMI (2001); 8) GeoTRACE-2 (2001); 9) GIFTS (2003); 10) MISTI (2005); 11) TIGRIS-1 (2005); 12) GeoDBSim (2007); and 13) TGRIST-2 (2008).

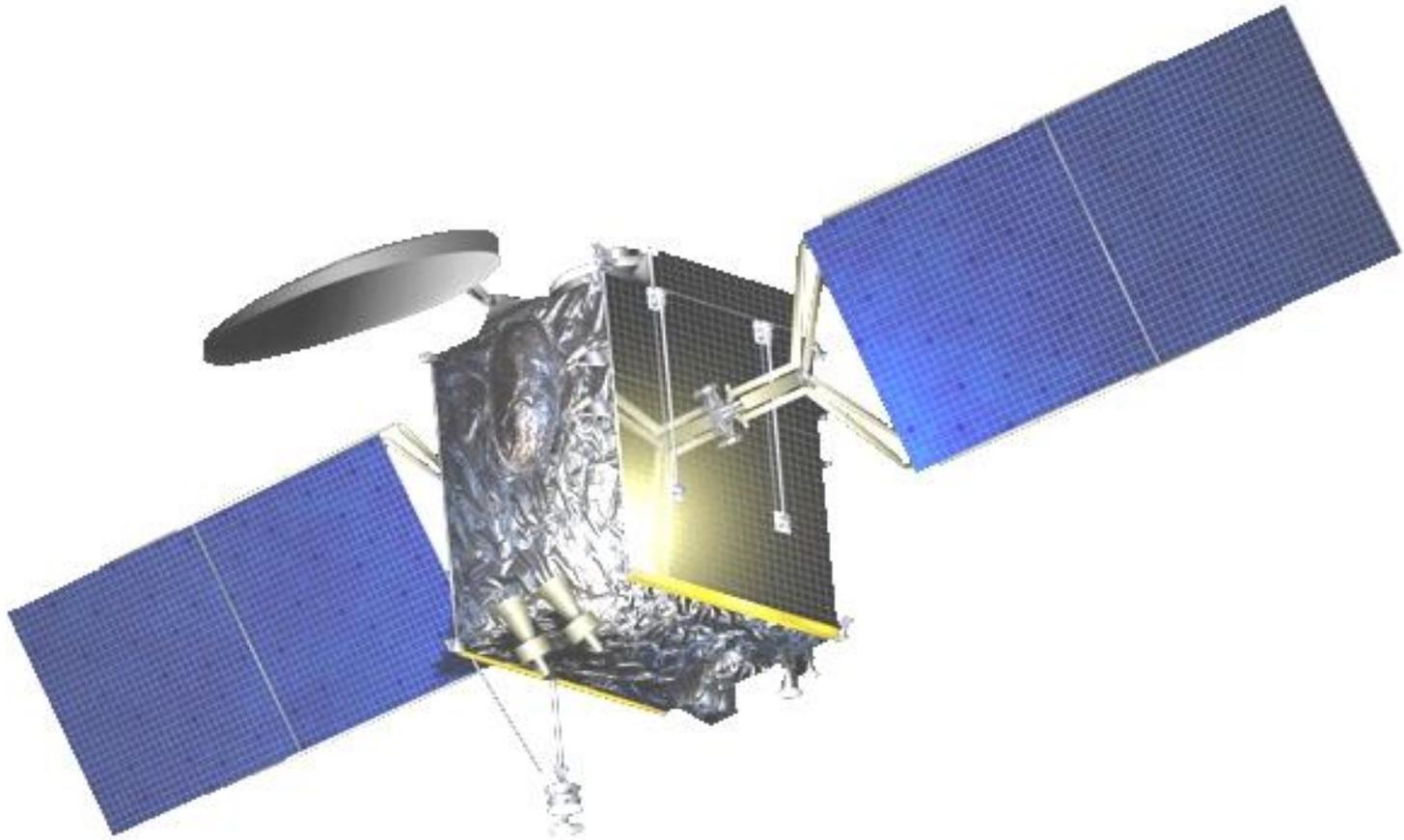
Successful GQR Payloads : 1) WAAS-1; 2) WAAS-2; 3) IRIS; 4) CHIRP; 5) GOLD; and 6) LD Camera.



Spacecraft Resources Available



An Example of a GQR Payload Accommodation Opportunity



3. Support the assessment of TRLs (Technology Readiness Level)

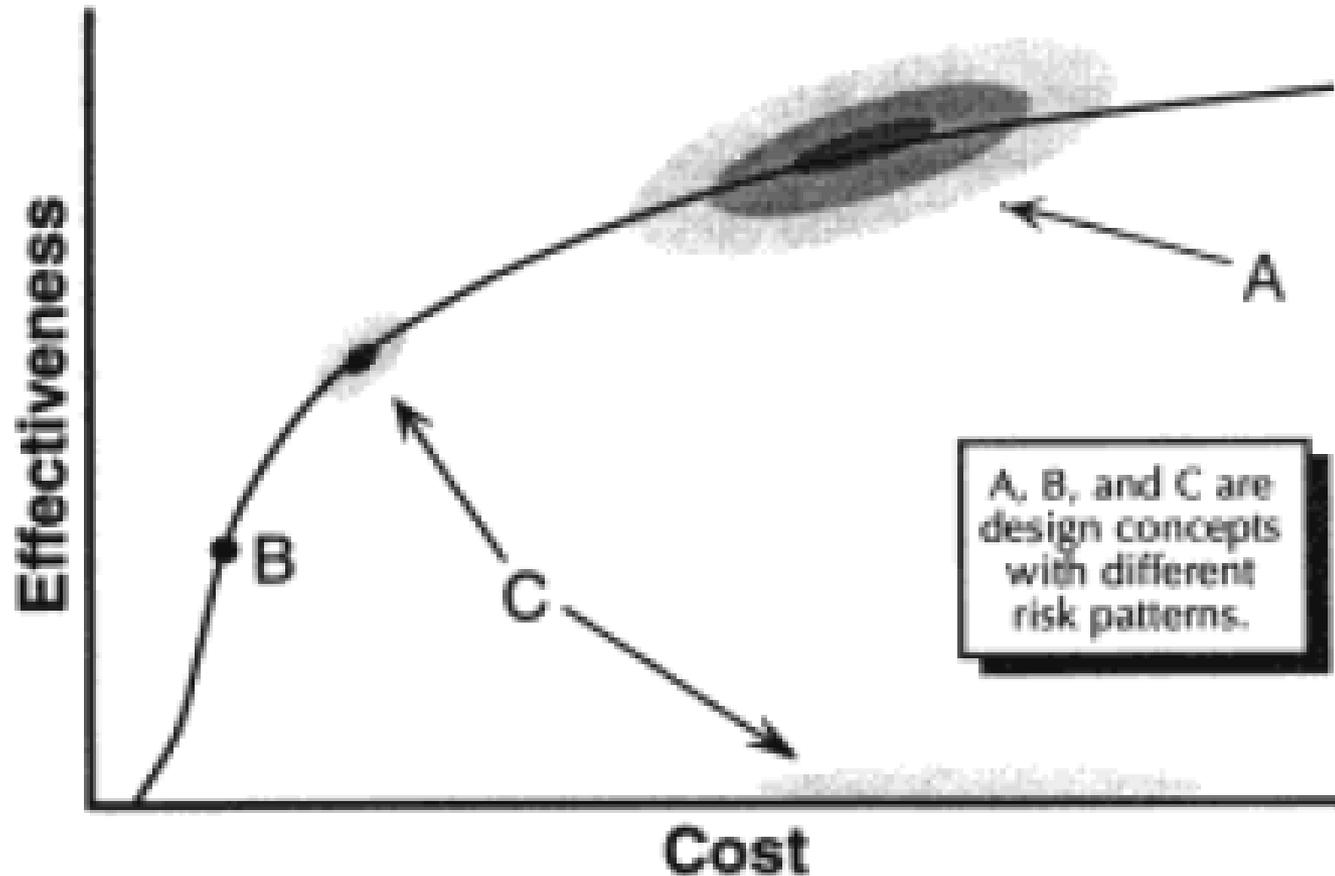


Figure 2--Estimates of Outcomes to be Obtained from Several Design Concepts Including Uncertainty.



Instrument Concepts and Threshold / Baseline Requirements



		Level 1 Requirements (science)								
		<i>Threshold Science Requirements</i>					<i>Baseline Science Requirements</i>			
Instrument Concept	Current TRL	TRL 6 Date	R1	R2	...	Rn	R100	R101	...	Rm
Instrument #1										
Instrument #2										
Instrument #3										
Instrument #4										
Instrument #5										

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GQR/Hosted Payload Summary



- Industry and Government organizations have recently become more interested in Hosted Payloads
- FAA held a Hosted Payload Workshop that included representatives from USAF/NSSO, USAF/STP, NRO, SMC, Navy, NOAA, NSF, ARC, GSFC, JSC, LaRC, JPL, and HQ/PA&E.
- The Air Force volunteered to take a leadership role in coordinating interagency cooperation with Hosted Payloads
- NASA plans to re establish the GQR Program. This will include awarding multiple IDIQ contracts to satellite vendors and providing SE support to payload developers. The goal is to have the program established to support the upcoming Venture Class AO (Fall '10?)
- A GQR website established and will be updated as the program is developed: <http://gqr.gsfc.nasa.gov>
- The Access to Space (ATS) website is re established to support the Rideshare process. The website's database will be upgraded to support matching payloads to flight opportunities: [http:// accesstospace.nasa.gov](http://accesstospace.nasa.gov)



Backup ...



4. Identify potential partnerships



- Are there Instrument partnerships (Korea)?
- Are there data partnerships (other platforms)?
- Are there satellite partnerships (NOAA/GOES)?
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GQR/Hosted Payload Overview



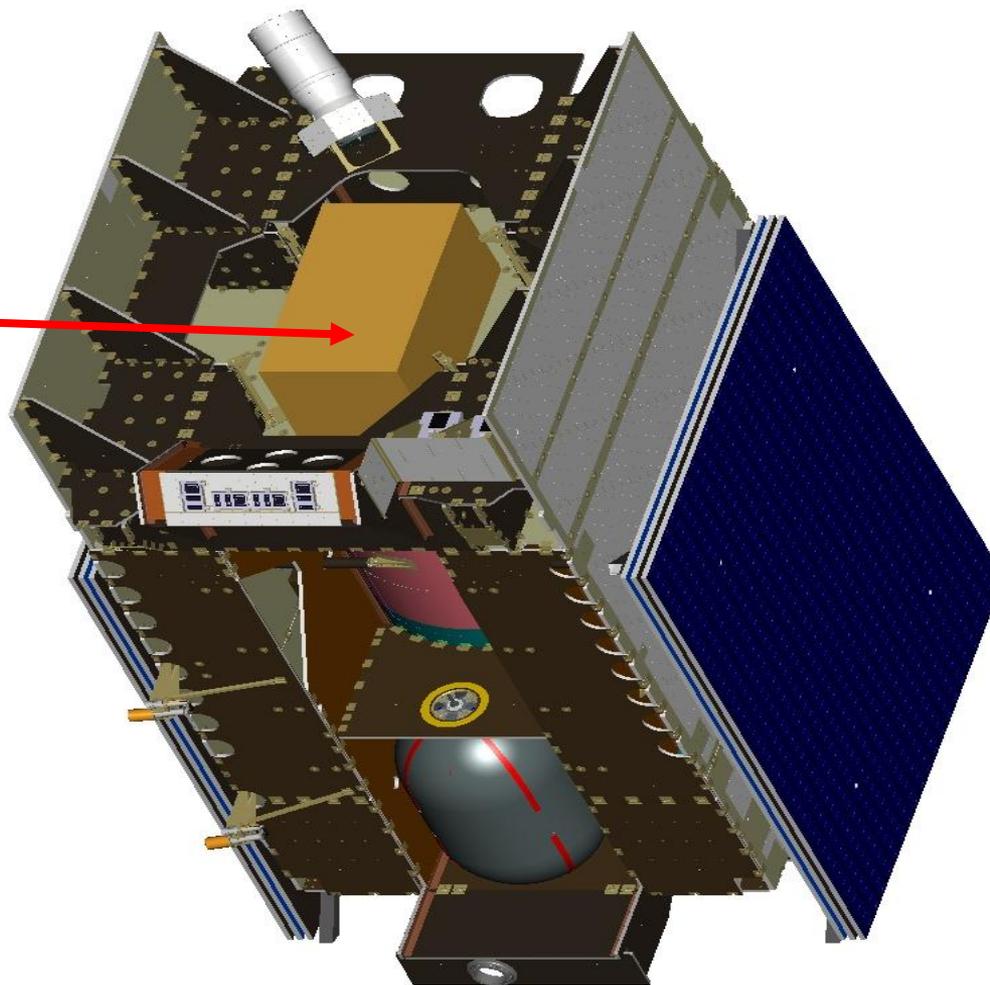
- Goal: To fly science instruments and technology demos on the excess capacity of commercial GEO communication satellites
- 1998/99 GQR Studies on Commercial Spacecraft Opportunities:
 - Average excess capacity: mass: 89kg, power: 460W & volume
 - Commercial: 4 US manufactures & 4+ owner/operators
- Changes at NASA and the spacecraft industry are creating opportunities for piggybacking on commercial satellites
- Owner/Operators provide: spacecraft accommodations; integration support; & ground station/mission ops support
- Commercial communication satellites have a 15 year mission life and GQR payloads use BOL capacity
- GQR flight opportunities will be added to the Access to Space website and ATS Rideshare database (<http://accesstospace.nasa.gov>)



Intelsat & Orbital: GQR Payload Example

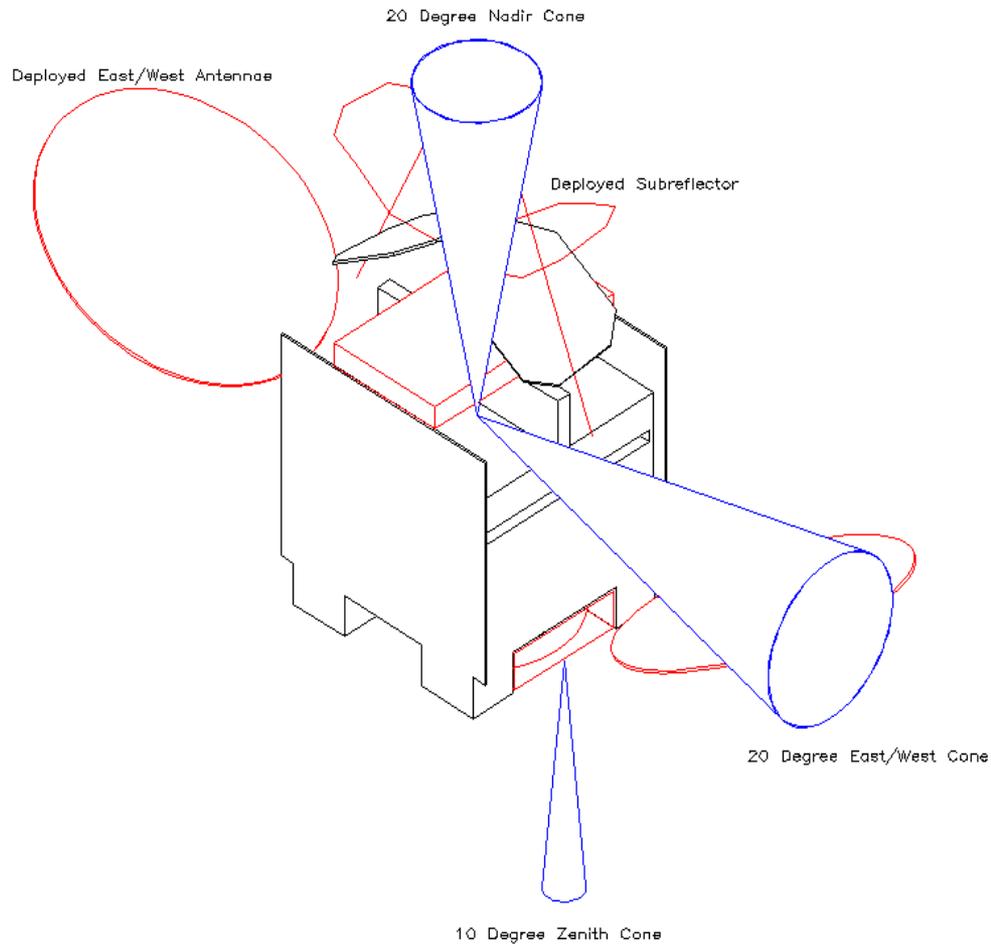


Sensor
Package



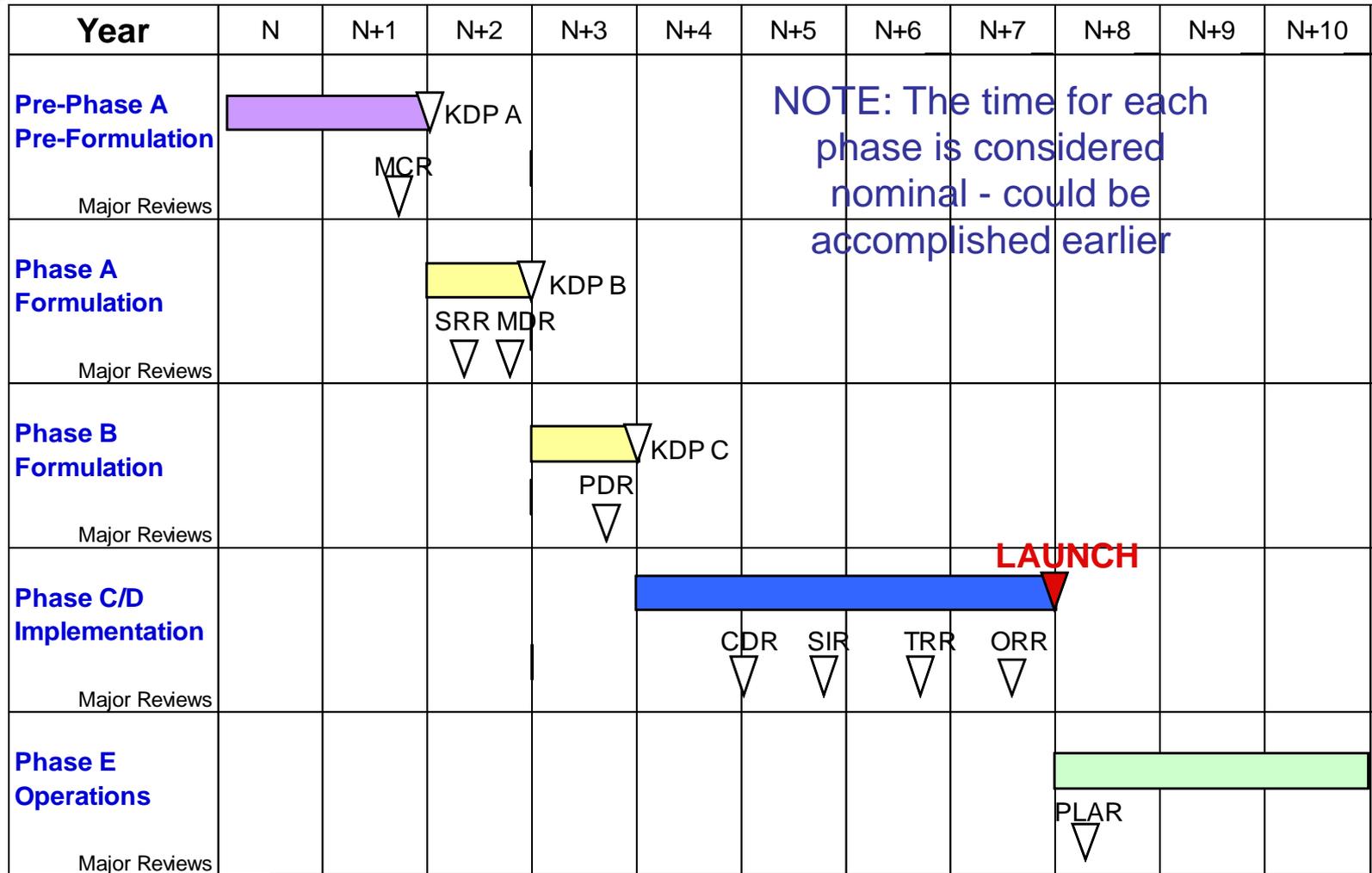


Boeing: GQR Field-of-View Example





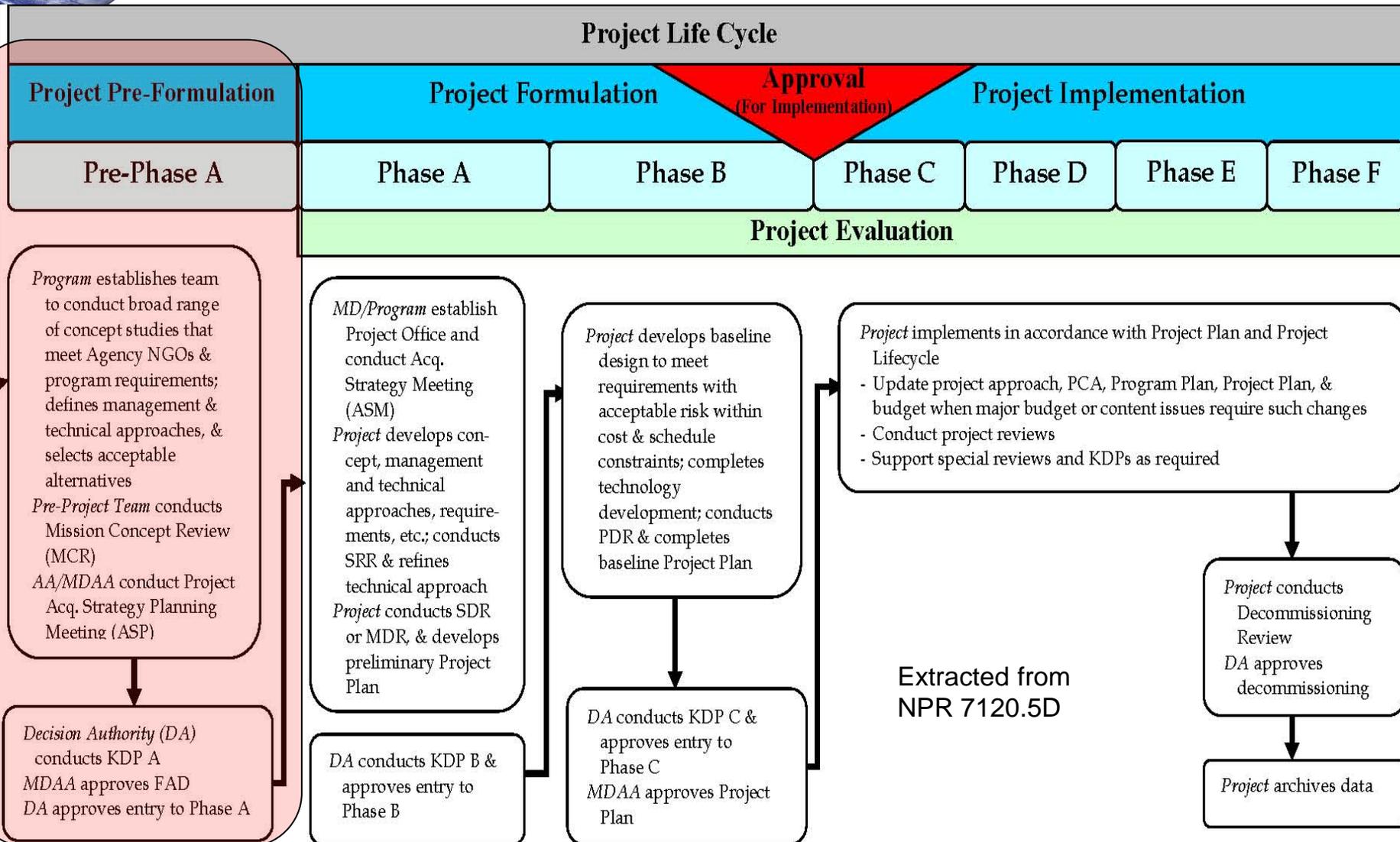
Notional Mission Timeline



NOTE: The time for each phase is considered nominal - could be accomplished earlier



Flight Project Lifecycle





Key Pre-Phase A Questions



- What science **MUST** this mission achieve?
 - What specific measurements?
 - To what accuracy?
 - What are the required data products?
- ↓
- What mission parameters can achieve the science?
 - What orbit (inclination/altitude)?
 - Which instruments?
 - What is the baseline mission duration?
 - How can NASA achieve these measurements?
 - Are there other missions required/desired to achieve the science?
 - Who can NASA partner with to achieve this mission?

Should be resolved ~ 12 months prior to KDP A

Should be resolved ~ 6 months prior to KDP A

Year	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Notional Mission Schedule Major Reviews			KDP A		KDP B		KDP C		LAUNCH		
		MCR	SRR	MDR	PDR		CDR	SIR	TRR	ORR	PLAR
		▽	▽	▽	▽		▽	▽	▽	▽	



Requirements Structure



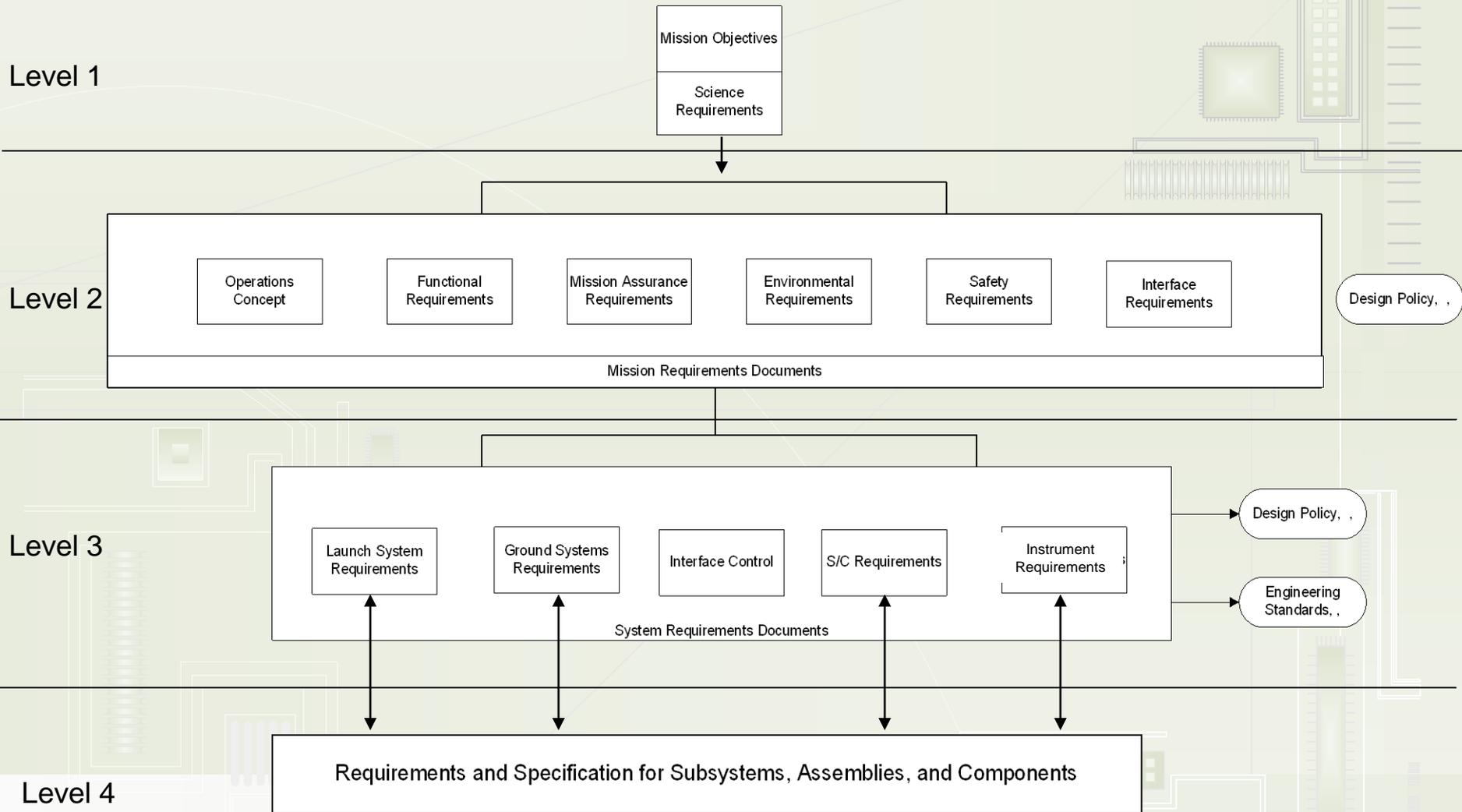
Level 1 Requirements: Science Investigation Requirements

Level 2 Requirements: Mission Functional Requirements

Level 3 Requirements: System and Interface Requirements (Instrument)

Level 4 Requirements: Element Requirements

Requirements Documentation



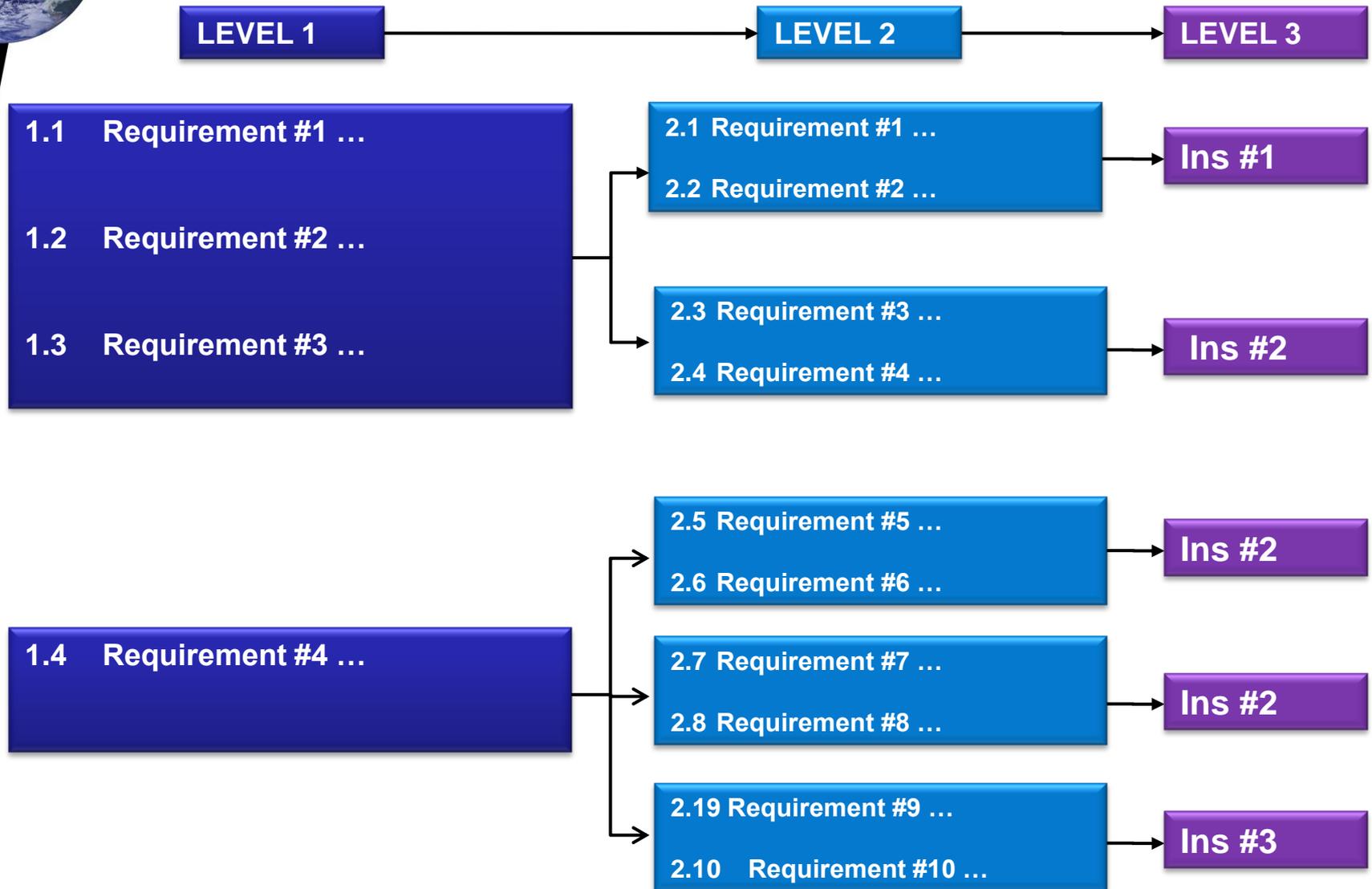


Requirements

- **Level 1 (Science) requirements** define what is necessary for the investigation to be successful. Level 1 requirements constitute a contract between the OSIRIS Principal Investigator (PI) and NASA Headquarters and can only be changed with the approval of both parties. These requirements are contained in a project plan.
- **Level 2 (Mission) requirements** define the mission functions that are needed to accomplish the level 1 requirements. These requirements are contained in a Mission Requirements Document and the Mission Assurance Requirements. Performance requirements are attached to each function. The level 2 requirements are controlled by the Project Manager, the Mission Systems Engineer and the Mission Assurance Manager. Mission Assurance Requirements also reside at this level and flowed down to the lower levels.
- **Level 3 (System) requirements** are the requirements of the space, ground and launch systems necessary to accomplish the total integrated mission. The requirements for each system are contained in a functional and performance specification for each systems and ICDs between systems.
- **Level 4 (Element) requirements** are the element functions and performance levels necessary to meet the system requirements. The element requirements identify products, subsystems and components that meet the level 3 requirements and the interfaces between those subsystems and products.



Science-Instrument Traceability



NPR 7123 requirements for MCR



Mission Concept Review

Entrance Criteria	Success Criteria
<ol style="list-style-type: none">1. Mission goals and objectives.2. Analysis of alternative concepts to show at least one is feasible.3. Concept of operations.4. Preliminary mission descope options.5. Preliminary risk assessment, including technologies and associated risk management/mitigation strategies and options.6. Conceptual test and evaluation strategy.7. Preliminary technical plans to achieve next phase.8. Defined MOEs and MOPs.9. Conceptual life-cycle support strategies (logistics, manufacturing, and operation).	<ol style="list-style-type: none">1. Mission objectives are clearly defined and stated and are unambiguous and internally consistent.2. The preliminary set of requirements satisfactorily provides a system that will meet the mission objectives.3. The mission is feasible. A solution has been identified that is technically feasible. A rough cost estimate is within an acceptable cost range.4. The concept evaluation criteria to be used in candidate systems evaluation have been identified and prioritized.5. The need for the mission has been clearly identified.6. The cost and schedule estimates are credible.7. An updated technical search was done to identify existing assets or products that could satisfy the mission or parts of the mission.8. Technical planning is sufficient to proceed to the next phase.9. Risk and mitigation strategies have been identified and are acceptable based on technical risk assessments.



MCR Guidelines



- **Concept Definition**
 - Must have sufficient fidelity to support trades, risk identification, and a credible cost estimate
 - Sufficient margins per NASA and implementing Center standards must be incorporated
 - Robustness
- **Technology Readiness and Risk Assessment**
 - Technology is at an appropriate maturity level (TRL 6). Risks should be identified and risk mitigation plans in place. Project should have a risk management system in place (the software and a primary manager)
- **Level 1 Requirements Definition**
 - Supported by documented trade studies, an SDT report, simulations, modeling, and analysis
 - Science requirements formally decomposed and traceable to mission element requirements (Level 2 & 3). Documentation for traceability exists and has been peer reviewed
- **Credible cost and schedule estimates supported by at least one independent estimate or assessment**
 - Estimates should be coordinated with the PE and the ESM-PO at least two months before the MCR itself. Surprises at the MCR itself will delay KDP-A.
 - Both cost and schedule must have reserves specified by Agency and implementing Center policies
 - Launch Vehicle availability and cost must address availability via NLS contracts
- **Credible descope options identified**
 - Options for cost containment exist and have been quantified
- **Partnering & Contributions**
 - Need to be identified with the notional content of MOU's (gives/gets) identified
- **Review Team, TOR, and IPAO**
 - 7120.5 D does not require a formal SRB for MCR. However, the review chair, agenda, and TOR should be coordinated with the implementing Center's Systems Review Office. The review team members should have independence from the Project, and at least half should be from an independent Center.